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ABSTRACT

The key to the survival of manufacturing industries in the South is the ability to innovate. Most of the responsibility for innovation rests on the technical skills of the labor force--not only the scientists and engineers who design the technologies but also the employees who ultimately will have to work with and understand the new technologies. In order to acquire these skills, potential technicians need schooling beyond high school. The South's two-year postsecondary institutions are in an enviable position. These schools are among the best in the nation and are in the position to teach not only technical skills but also the critical thinking and problem-solving skills that will be needed by the "Renaissance" technician of the future who needs to keep up with ever-changing technology. Four programs are models of the innovation and excellence that are needed by technical schools. These exemplary programs are (1) the Robotics Resource Center, Piedmont Technical College, Greenwood, South Carolina; (2) the Noble Center for Advancing Technology, Oklahoma State University, Technical Branch, Okmulgee, Oklahoma; (3) the program in biomedical equipment technology at Stanly Technical College, Albemarle, North Carolina; and (4) the Center for Productivity, Innovation, and Technology, Chattanooga State Technical Community College, Chattanooga, Tennessee. These programs represent the best of a certain type of technical education. Yet, there are still nagging questions related to goals, enrollment patterns and access, ability to measure and assess programs, and links to secondary vocational education. Planning to address these problems is needed to clarify and strengthen the two-year colleges in their role of preparing workers for the future. (KC)

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MODEL PROGRAMS FOR SOUTHERN ECONOMIC DEVELOPMENT

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# THE EDUCATION OF THE RENAISSANCE TECHNICIAN

## POSTSECONDARY VOCATIONAL-TECHNICAL EDUCATION IN THE SOUTH

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### INTRODUCTION

The key to the survival of manufacturing industries in the South is the ability to innovate, and most of the responsibility for innovation rests on the technical skills of the labor force -- not only the scientists and engineers who design the technologies but also the employees who ultimately will have to work with and understand the new technologies. The latter may be the most critical need in the region. According to a major study in the region's most manufacturing-dependent state, "the biggest obstacle to installing sophisticated equipment and robots in North Carolina's factories is the scarcity of trained people at the plants." Such a situation in a state that is ranked among the leaders in technical education is the rule, not the exception. The argument that with proper design new technologies will eliminate the human factor simply has not proven true. The more sophisticated the technology, the more important are human intellect, judgment, and initiative.

The growing demand is for technically trained workers not only with skills to use new equipment but with the ability to understand the equipment and its place in the total manufacturing operation and to respond swiftly and independently to the inevitable problems that occur whenever programmed technologies replace craft and experience. In fact, with modern technology and management methods and more fully integrated production systems, business relies more on its nonprofessional technical support staff than ever before.

This marks a significant change from the past, when the title "technician" implied a high level of specialization. Now, as Dr. Ray

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Morrison, High Technology Coordinator for Georgia's State Board of Postsecondary Education explains, "Industry wants not only the good technician, but a good communicator and a person well-versed in universally based math and science." Modern businesses seek the individual who, in addition to technical competence, is able to understand how the entire production and business systems fit together, can tackle complex technical, systemic, and interpersonal problems, can contribute to more effective use of new technology, and is able to adapt to change. In other words, they want the modern, technical equivalent of the Renaissance Man -- or Woman.

Unlike the Renaissance Man of the fifteenth and sixteenth centuries, who could acquire a wide range of skills and diverse knowledge because the world was simpler, the Renaissance Technican of today and tommorow must acquire broader-based skills and knowledge because the world is more complex and changing more quickly. To the Renaissance Man, diversity and adaptability were luxuries; to the Renaissance Technician, they are necessities, critical to the successful modernization of the South's economy.

The implications for vocational education are pervasive. Potential renaissance technicians can no longer acquire what they will need in just twelve years of formal schooling. High school vocational education will have to stop thinking of itself primarily as a terminal program aimed at immediate employment and instead think about placing greater emphasis on preparation for additional technical education. The primary responsibility for technical education will rest with the South's associate degree programs in its technical institutes and community colleges.

The South's two-year school system is in an enviable position. While as a whole the region is still catching up with elementary and secondary education and still working to build more world-class universities, its two-year postsecondary schools are the pride of the nation. Other regions are taking their cues from the South. With imitation the sincerest form of flattery, they have emulated policies and programs that have been in operation in North and South Carolina, Oklahoma, and other southern states for two decades and more. The South has, as a region, the most extensive and sophisticated system of two-year, vocationally oriented technical institutes and community colleges in the nation.

Schools that offer associate degree and certificate technical programs serve a dual economic development function in the region: they provide a pool of technicians to support technological development, and they provide businesses considering expansion or location with an institutional base for replacing technically trained people and upgrading the technical skills of their existing employees. The availability of a strong technical school is a factor in the economic climate of the region, and the quality and quantity of the technical workforce is a factor affecting the economic capacity of the region.

## THE EVOLUTION OF POSTSECONDARY TECHNICAL EDUCATION

Up until mid-century, programs for technical occupations that required less than a baccalaureate degree were located in the South's public high schools. Those who wanted more occupationally specific training could enroll in one of the many proprietary programs, advertised in such places as the back pages of Popular Mechanics, inside matchbook covers, and on panels in city buses: "Learn Radio Repair in Twenty Easy Lessons and Earn as Much as $50 per Week."

By the end of the 1960s, however, two events piqued national interest in more systematic and higher-quality technical education. One was Sputnik, which led to the National Defense Education Act of 1957 authorizing funds for the training of technicians for occupations requiring scientific knowledge. The other was a spurt of public and private sector interest in automation, sparked by advances in numerical control machine tools in the space and defense industries.

In 1961, President Kennedy convened a Panel of Consultants on Vocational Education and charged it with recommending changes in federal policy to meet future industrial and military needs. As he told the Congress, "The technical changes which have occurred in all occupations call for a review and re-evaluation of these [vocational education] Acts, with a view toward modernization." One of the Panel's suggestions was to transfer responsibility for technical programs to postsecondary institutions which would, where appropriate, confer two-year technical Associate Degrees. Its final report stated:

> Because of advancing technology, many jobs require more technical proficiency and greater knowledge of mathematics and science. These jobs also often require more mature persons than youth of high school age. As a result, attention is increasingly focused on postsecondary vocational and technical education.[1]

While not a binding document, the Panel's work was instrumental in reformulating vocational education in the Vocational Education Act of 1963. The new law set aside dollars for adult postsecondary vocational education, re-categorized vocational education into eight occupational areas, and combined appropriations, which previously went directly to particular occupational areas, into block grants to each state. One of the areas was "Technical Occupations," most of which were expected to required education beyond high school.

Even with support at the national level, implementing the recommendation for expanded postsecondary vocational education proved no easy task. For one thing, postsecondary institutions competed with high schools for funding, and in most states the secondary school state agencies controlled the purse strings. Since 1937, the American Association of Junior Colleges (AAJC) had lobbied unsuccessfully for a share of federal vocational education dollars;[2] the entrenched secondary vocational education agencies naturally wanted to retain as much of the federal money as possible.

Further, up until the 1960s most two-year institutions were not vocationally oriented. Originally called junior colleges, they emphasized the liberal arts with the goal of easing the transition from high school to university. As late as 1970, two-thirds of those enrolling in two-year schools expected to continue on for their Bachelor's degree. Even the Manpower Development Act of 1962 (MDTA), originally enacted to address the expected retraining needs due to automation, was more apt to conduct its training in high schools, which had better-equipped vocational shops, than in postsecondary institutions. A number of critics even maintained that the real purpose of community colleges was actually perverse -- to limit the higher education aspirations of marginally prepared, usually lower-class, youth.[3]

Equally important, there was no clear signal from industry that the technical skills the Panel recommended were wanted or needed. The general belief in the 1960s -- as promulgated by those who produced new automated equipment -- was that new manufacturing technologies would reduce skill needs, labor costs, and labor dependency. Many businesses still operated under the scientific management theories of Taylorism, which subdivided and simplified work as much as possible, and they wanted individuals who <u>were</u> programmed (to unquestioningly perform assigned tasks), not individuals who <u>could</u> program (think creatively). True technicians were only sought to work in corporate research labs or in experimental programs. Consequently, most of the resources of the two-year schools were devoted to the liberal arts, to programs which replicated high school programs, or to short-term customized training in support of industry expansion or relocation.

By the beginning of the 1970s, it was evident that automation had <u>not</u> occurred as rapidly as predicted. The highly regarded numerical control machine tools (N/C) developed in the 1950s were still as rare as the bald eagle -- outside of the aerospace and military industries, where equipment was leased from the government or subsidized.[4] Enrollments in "Technical Programs" remained low throughout the 1960s and the goals of MDTA, established in response to automation, were reoriented toward training disadvantaged workers rather than responding to technological change.

Only in recent years, spurred by the changing requirements of the workplace and buttressed by accelerating technological advances due to foreign competition, has the demand for highly technical vocational skills been reinvigorated. Yet there are unresolved issues concerning the future of technical vocational education.

## JOBS, WORK, AND TECHNOLOGICAL CHANGE

The key factors that influence local, state, and federal investments in, and programs for, technical vocational education are (1) the scale of the demand for technical occupations; (2) the effects of technology on work -- whether it requires more or fewer skills; and (3) innovations in management methods that alter the demands on technically trained workers. The principal arguments against preparing youth for more highly skilled work and making greater investments in the two-year

technical associate degree and certificate programs are (1) that the total requirement for work in high-tech industries and in high-tech occupations will be small relative to the size of the workforce and (2) that new technologies will increasingly deskill work. Proponents of expanding technical education claim that technology will substantially alter the structure of work and that, as management changes, higher-order thinking skills will be more highly valued and more effectively utilized.

## Will Demand for Technical Occupations Continue to Rise?

Since occupational demand ostensibly drives the delivery of education and training programs, policy makers must know whether the demand justifies increased investments in technical training. Critics who contend that demand for technical skills is overstated generally base their analyses on either (a) projections of growth of occupations with titles that imply technology or (b) projections of growth in jobs in high-tech industries (which are classified as "high-tech" according to either, or both, industry expenditures on R&D and percent of industry employees in technical occupations).

It is easy to underestimate the importance of technical training, particularly if occupations classified as technical are too narrowly defined. For example, the Bureau of Labor Statistics (BLS) concludes that high-tech occupations will comprise only 6 percent of the labor force in 1995,[5] but their definition of high-tech occupations includes six specific occupations and excludes even occupations such as computer service technicians. Dental technicians, nurses,[6] and hygienists, and paramedics have been termed "low tech" occupations,[7] even though medical technology is changing rapidly, and all of these technicians must be able to stay abreast of the technology. And most analyses ignore marketing and sales support staff for technical products, even though this work requires a solid technical background. Despite the fact that many technical marketing personnel are recruited from schools of engineering, marketing rarely shows up as a "high-tech" occupation. A person working on numerical controlled machines might be called a machinist even if the skills needed to tend and understand the equipment are quite technical.

Thus, projections based on occupational titles are inherently suspect since they may not accurately reflect the technology of the workplace.[8] Even though BLS attempts to update job descriptions in its Dictionary of Occupational Titles, the publication is hopelessly out-of-date and lacks a process for staying current.

The National Commission for Employment Policies, in a thorough analysis of occupations held by youth -- although hampered by definitional problems -- estimated from census data that in 1980 15.5 percent of adults between the ages of 20 and 24 held technology-related jobs, and all indications are that demand is going to remain strong.[9] In September 1986, the BLS reported that, with the nation's unemployment rate at 6.8 percent, the occupational category "technicians and related support" had an unemployment rate of only 2.9 percent -- the lowest of any nonprofessional category.

The growth of industries designated as "high tech" is an even less reliable predictor of demand for technical education and skills. Predictions for employment in high-tech industries in 1995 are on the order of 6 percent of the workforce. But, obviously, the production divisions of many high-tech industries are low-skilled assembly operations. Technical skills and scientific knowledge are much more closely related to the equipment used on the job and to the style of management than to the technology used in the product.

## Does Technology Require More Skills or Fewer Skills?

Do technological innovations depend on higher-order technical and thinking skills or do they simplify and routinize work. Much blue collar work has always required more problem-solving and more theory than assumed by educators -- as Robert Pirsig so eloquently pointed out in Zen and the Art of Motorcycyle Maintenance.

> An untrained observer will see only physical labor and often get the idea that physical labor is mainly what the mechanic does. Actually the physical labor is the smallest and easiest part of what the mechanic does. By far the greatest part of his work is careful observation and precise thinking....They [mechanics] are using the experiment as part of a program to expand their hierarchy of knowledge of the faulty motorcycle and compare it to the correct hierarchy in their mind. They are looking at underlying form.[10]

There is little doubt that in the past industry did intend for technology to deskill work. The bulk of historical evidence reveals that industry expected automation and new technologies to simplify work, just as the manufacturers of the technologies promised, and that investments in technologically advanced equipment often were made on that basis. What occurred, however, was quite different from what was anticipated. According to an extensive study of the implementation of numerical control machine tool (N/C) equipment by David Nobel:

> Management learned the hard way, from the trials of experience, that with N/C they had invariably to depend upon the work force as much or even more than they did before. Optimal utilization of the expensive new equipment was now the key to economical, quality production, and the skills and cooperation of the workers were the key to optimal utilization.[11]

The weight of evidence from those who have spent time on the shop floors studying technological change indicates that modern, technologically advanced equipment does not remove the need for human decisions and judgment. If anything, in an interconnected system, errors and anomolies are more expensive and require quicker attention. Larry Hirshhorn's research represents the growing belief among engineers that "error is inevitable in automative systems -- if there are always to be modes of failures that cannot be automatically regulated by feedback-based controls -- then learning must be instituted in order to prepare workers for intervening in moments of unexpected systematic failure....Historically, we would then see the worker moving from being

the controlled element in the production process to operating the controls to controlling the controls."[12]

This writer's experience as a manufacturing engineer in the 1960s supports that view. The most qualified, most experienced, and highest-paid workers were selected to use the most costly, most automated equipment. As a manager told a noted automation researcher recently, "You don't want to save $2 per hour by putting an unskilled operator on expensive equipment."[13]

## Modern Management and the Renaissance Technician

Perhaps the most important information needed to design vocational educational policies and programs for the renaissance technician is how management intends to organize around technological changes. New management philosophies are replacing the hierarchical, authoritarian scientific management concepts known as "Taylorism," and more modern management recognizes the role workers' experience and increased education can have on productivity. The National Research Council (NRC) warns that as impressive as technical advances are, they will have only a limited impact unless companies also revamp their internal structure and decision-making procedures. The Manufacturing Studies Board of NRC argues that:

> Over the years our answer was to specialize. If one guy couldn't do everything, then we got three guys to do one-third of it each. We subdivided and subdivided without realizing...its drawbacks. Company managers have to break down the distinctions between workers and managers and push decision-making down to the lowest possible level.[14]

The manager of a new, highly automated General Electric plant has already put that suggestion into practice. The design of his plant's system is based on the presumption that "The more the structure requires employees to be fully involved in their jobs and in solving the problems they have an impact on, the less supervision and management intervention is needed."[15]

According to a recent special feature in Business Week, "contrary to the engineer's vision of factories run by robots, the high-tech work place depends more than ever on people....We're moving increasingly into dangerous, unforgiving technology that cannot be operated safely without committed people."[16] Advanced computer technology calls for a radical change in traditional work practices. Work in the new environment is "multiskilled and performed by teamwork where possible; doing and thinking are combined."

These patterns of new management will continue to spread, and eventually they will revamp vocational education and how it prepares people for work. But this will not occur overnight. Thus far, most companies still use management styles out of the past, and both managers and educators are slow to value the experience and knowledge of employees when making business decisions. To date, most education

programs remain rooted in the traditional workplace. According to a recent study by the U.S. Office of Technology Assessment:

> Development of multiple skills and the cross-training of workers to perform a variety of functions on the shop floor are emerging instructional requirements for automated facilities, although not reflected as yet in many established instructional programs.[17]

This issue of Foresight describes those programs that make it possible for modern management to move toward increased reliance on the knowledge and experience of employees, better work relationships, and a better workplace environment by preparing a different sort of technician -- one with technical skills plus knowledge of business, human relations, and the ability to learn and relearn.

## TWO-YEAR INSTITUTIONS TODAY

Two-year postsecondary vocational-technical programs in community colleges, technical institutes, area vocational centers, and universities have realized the fastest growth of any sector of education. Based on data collected by the American Association of Community and Junior Colleges (AACJC), from 1955 to 1975, enrollments in these schools for college credit rose 261 percent, from 0.7 million to 3.5 million, shown in Figure 1. Between 1975 and 1985, enrollments grew 114 percent, to 4.8 million -- while enrollments in the rest of higher education grew much more slowly. These enrollment figures include students in two-year associate degree programs, one-year or shorter certificate programs, and programs aimed at transfer to four-year institutions and exclude many who are in not-for-credit retraining or job upgrading programs.

In the South, nearly one million students were reported by AACJC as enrolled in two-year schools in 1981, although in many states the reported total did not include those in non-collegiate schools such as area vocational centers or in adult programs offered in rural high schools, shown in Table 1.

The proportion of postsecondary students enrolled in occupationally specific vocational education programs is about one-half and growing; one-third are full-time students, and two-thirds are half-time students. About one out of five of those enrolled are in associate degree programs; in 1984-85 there were about 470,000 associate degrees conferred.

Two-year vocational education programs are doing a credible if not a superb job of preparing students for technological change. As in any system, quality varies considerably among states and among institutions. Too many schools unfortunately still focus on programs that are better taught in the high schools, on programs that are short-term, customized training programs with little attention to flexibility and transferability of skills, and on programs that focus too much on specific job procedures and too little on broader knowledge of the

TABLE 1

## FOR-CREDIT ENROLLMENTS IN TWO-YEAR COLLEGES, 1985

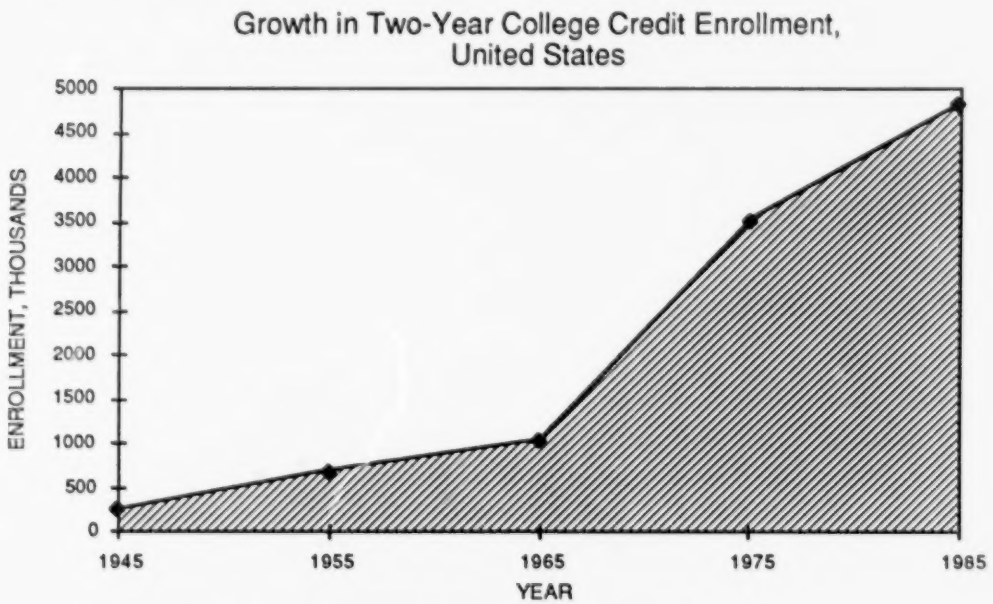
| State | Enrollment[1] 1000's |
|---|---|
| Alabama | 211.3[2] |
| Arkansas | 12.7 |
| Florida | 238.3 |
| Georgia | 35.9 |
| Kentucky | 26.9 |
| Louisiana | 14.4 |
| Mississippi | 38.8 |
| North Carolina | 131.7 |
| Oklahoma | 61.3 |
| Puerto Rico | 31.1 |
| South Carolina | 29.9 |
| Tennessee | 48.2 |
| Virginia | 108.7 |
| SGPB | 999.7 |
| United States | 4730.2 |

Source: American Association of Community and Junior Colleges (AACJC)

(1) These only include postsecondary programs offered in colleges as reported to AACJC, may not correspond to state numbers that include programs off-site or in area vocational centers. In Georgia, for example, an additional 82.8 thousand are enrolled in programs at area vocational centers, but about half are in short-term adult programs.

(2) Alabama's figure was revised from state reports.

FIGURE 1




Source: American Association of Community and Junior Colleges

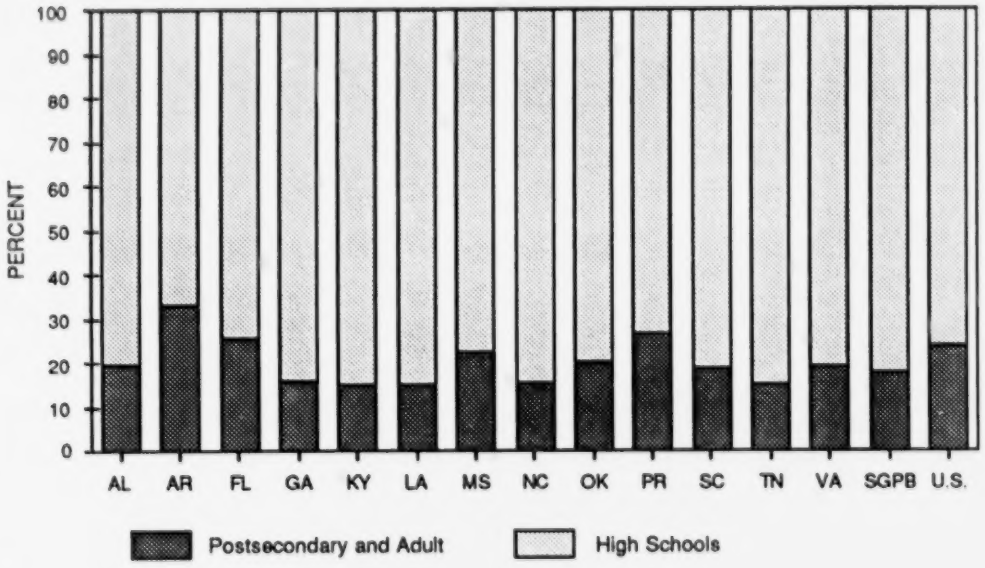
business in which the job exists, on communications and human relations, and on basic conceptual skills.

To be fair, however, postsecondary associate degree vocational education in the South has had to fight an uphill battle for support. The federal government and many state legislatures still consider the two-year vocational education institutions as supplementary, not the primary delivery systems of vocational education. Portions of federal vocational education act funds still must be set aside for the postsecondary programs to ensure that all dollars are not captured by the high schools. Up until 1984, the prescribed set aside was only 15 percent of the basic grant to the states. In 1981, SGPB states allocated slightly more -- about one-fifth of their federal vocational education funds to postsecondary (degree) and adult (non-degree) programs, shown in Figure 2. However, in most of the states there were more full-time equivalent students in postsecondary occupational programs than in secondary occupational programs.* Even in North Carolina, which has a history of strong support for community colleges, appropriations per student declined by 25 percent between 1973 and 1983.[18]

*Although there are about five times as many high school students enrolled in vocational education as postsecondary students, only about one out of five of those in high school is in an occupational program and the typical high school student takes less than half as many occupationally specific courses as the postsecondary student.

FIGURE 2

Division of Federal Vocational Education Act Funds
Between High School Programs and
Postsecondary and Adult Programs,
Fiscal Year 1981




Source: U.S. Department of Education, Vocational Education Data System

It is true that postsecondary schools have other sources of funds available to them -- JTPA funds, tuition, and Higher Education Act funds, including federal student financial aid -- but high school vocational education has access to the large amounts of state and local revenues that support public education, which comes to about $3000 per student in the South.

One way to judge the emphasis two-year schools place on technical occupations is to note changes in enrollments in the occupational area called "Technical Occupations," one of eight occupational areas designated by the vocational education act. However, these numbers must be used cautiously because just as job titles do not accurately reflect technical skill needs. The classification does not nearly include all technical programs. Many highly technical programs are included under, for example, health occupations, trade and industrial programs, and office occupations. Further, the enrollment data available are only required to include programs that receive federal vocational education funds. In Oklahoma, for instance, associate degree programs for technical occupations are located at state universities and are not eligible for these federal funds and thus are not counted.

## FOUR EXEMPLARY PROGRAMS

The South, which already has the most extensive network of community colleges and technical institutes in the nation, is also leading the drive to adapt program content to the changing economy. Many of its two-year schools originally were built with federal assistance from economic development programs to support business expansion and location. Thus vocational education was concentrated more heavily on short-term, business-specific skills than on associate degree programs. Today states are re-evaluating their postsecondary programs with an eye toward providing more flexible technically trained graduates. Some have formal procedures in place. Florida's High Technology and Industry Council conducted a systematic evaluation of its electronics programs and picked five schools to become Centers for Specialization in Electronics. North Carolina's Department of Community Colleges conducted a series of industry roundtables to obtain indsutries' views of skill and education needs and desires.

Programs are more costly than traditional customized training, much of which can take place at the plant and is limited to company-specific conditions, but in the long term these "renaissance" programs may actually be less expensive because they will reduce the need for subsequent retraining. Because of the immediate costs, however, states are identifying specific niches for schools and avoiding costly duplication of technical programs in too many locations.

This issue of Foresight describes four model programs, each of which has a specific strength or uses an innovative approach. One is in South Carolina, one in Tennessee, one in Oklahoma, and one in Pennsylvania. What they all have in common, however, is that they try to provide students in technical programs with a broad set of technical skills and knowledge to prepare them to adapt and change with the technology, to be able to learn on and from the job, to act

independently and decisively in crisis situations, and to use their experiences and knowledge to contribute to innovation.

The program at Piedmont Technical Institute in Greenwood, South Carolina houses a Robotics Resource Center that responds in new ways to the broad-based skill and knowledge requirements of the technical workplace. The program at Oklahoma State University, Technical Branch, is unusual because it is located in a four-year land grant college and draws students from across the state. At Chattanooga State Technical Institute, the Center for Productivity, Innovation & Technology provides one of the most sophisticated and comprehensive automation training facilities in the South. And at Stanly Technical College, a Biomedical Equipment Technology Program aimed at one of the nation's fastest growing industries, was selected by the state as North Carolina's most effective postsecondary program.

Each of the four programs selected uses an approach to technical training that assumes a work environment that is changing both technologically and socially. The curriculum of each of the programs includes strong basic scientific and interdisciplinary skills. Each has a vision of the technician of the future as a form of renaissance worker, who will be able to adapt readily to change and to apply a wide range of skills and knowledge to technical and innovative situations.

ROBOTICS RESOURCE CENTER
PIEDMONT TECHNICAL COLLEGE
GREENWOOD, SOUTH CAROLINA

South Carolina is recognized as one of, if not the, nation's leader in postsecondary technical education and among the first to recognize and establish the link between its technical colleges and its economic development agency. Its 16 technical institutes, each of which serves a cluster of counties, are easily accessible to virtually the entire state's population. The pride of the state's programs in the past has been its Special Schools Program, the customized training offered to attract new industry and encourage expansions.

Today, however, the state is turning to new economic development strategies, which are based more on entrepreneurship and technology-based development. More advanced training has surpassed the short-term programs as the strength of the system, and that requires greater concentration of resources.

One result is that the South Carolina Board of Technical and Comprehensive Education recommended the creation of six major centers throughout the state, each devoted to a different discipline. As a result, the state charged six technical colleges with developing educational expertise and national recognition in five particular scientific areas. Greenville Technical College has an Advanced Machine Tool Technology Center; Tri-County Technical Institute has a Microelectronics Resource Center; York Technical College has a Computer Applications Center; Sumter Technical College has a Water Quality

Institute; and, of course, Piedmont Technical College in Greenwood has a Robotics Resource Center, which is featured in this issue of Foresight.

Sites were selected on the basis of the schools' strengths but also on the basis of the state's economic development plan. The decision to locate the robotics program in Greenwood, for example, was based in part on Cincinnati-Milacron, a major robotics manufacturer, locating in the vicinity and a nearby major manufacturer making a major investment in robotics. In 1981, the Center began a two-year Associate Degree program in Automated Manufacturing Technology, which, according to Piedmont Technical College President Lex Walters, will eventually become the "prototype" for Associate Degree programs in Robotics.

Curriculum development at the Center responds to the shift in manufacturing automation from hardware-dependent to programming-dependent automation. According to James Rehg, former Director of the Robotics Resource Center, the program-dependent manufacturing system being developed today requires a workforce with strong communication and problem-solving skills, as well as scientific technological skills. His philosophy of vocational education epitomizes the needs of the renaissance technician of the future. Rehg told an audience of vocational educators in 1982 that new technologies require a diversity of skills. "Individuals have to be trained to handle interdisciplinary chores. Systems solution is what industry is going to be needing."[19]

The program at Piedmont Technical College is consistent with this vision of the future of the manufacturing workplace. The curricula are indicative of both the breadth and rigor of the programs. Students take courses, such as Sensor and Systems Interface, Workcell Design, Robotics System Operation, Numerical Control Manufacturing, and AC and DC Circuits in addition to more basic courses in scientific and mathematical concepts. The latter must include one unit of calculus, two units of algebra and trigonometry, and three units of either physics or chemistry plus units that concentrate on communications and writing skills. Given the rigorous demands of the associate degree program, about 35 to 40 percent of the students have to take some remedial work prior to entering.

The key to the program's innovativeness is its delivery system for factory automation training, the educational robot workcell. Rehg describes the workcells as follows:

> The educational workcells permit the problem-solving and programming exercises to be varied from basic to highly complex to meet a wide range of training needs.... educational workcells support team training and group problem solving. In addition, the written and oral communication skills vital in an automated operation can be taught in the group setting.[20]

The use of the Center and the workcell is by no means restricted to students in the Automated Manufacturing Technology program. Students in four other technical programs all make extensive use of the facility: Engineering Graphics; Electronics Engineering; General Engineering; and

Industrial Engineering. Each quarter about 100-150 students take courses in the Center, and during the summer quarter about 200 students, including employees from local industries being retrained and technical instructors learning how to teach the use of the equipment are in the Center.

Moreover, in keeping with its original goal of sharing information on automation training, the Center is involved in various programs with both industry and educators through seminars and workshops. In the summer of 1986, four one-week seminars were conducted at the Center, two for industry and two for educators. Since its inception, the Center's seminars and workshops have served representatives from 37 states and numerous foreign countries, including a series of exchanges with representatives from other countries. In the past year, 432 business people and educators took a cumulative total of 5,284 hours of training at the Center.

The Robotics Resource Center also conducts plant-specific, on-the-job industry training and retraining. The Center has been providing pre-employment training in robotics to new workers at the Globe Battery Division of Johnston Controls in West Union, which will be the most highly automated plant in South Carolina. The plant will be operated according to the team concept, requiring the type of training in group problem-solving that Piedmont Tech offers. The Center trained all personnel (management and labor alike) at Stanley Tool in Cheraw, South Carolina in introductory robotics and helped it convert to the workcell operation format.

Costs and Revenues

The Robotics Resource Center began with about $150,000, which was used to renovate an existing 1,000 square feet of laboratory space at the college. The state provided about two-thirds of the funds and the rest came from local sources -- county payments to the college and foundation support. Businesses in the vicinity donated about $250,000 of equipment, with a large share from Cincinnati-Milacron.

The annual operating expenses are difficult to assess because the Resource Center is included within the budget of the college. Some of the costs and revenues, however, can be assigned directly to the Center. For example, the state provides $42,000 for a director and some expenses, which is its contribution to the costs of maintaining the six Centers of Technical Excellence. The state provides about $25,000 for disposable supplies and equipment. Two faculty are assigned by and paid for by the school, at a cost of about $55,000, and maintenance is covered by the college. The college's contributions come primarily from student tuition and assessments to each of the seven counties, which are made in proportion to the number of students from that county in attendance.

Student enrollment is not limited for financial reasons. Most of the students receive some form of student aid -- either Pell grants, GSL loans, or local scholarships. Given the complexity of the funding

mechanisms, no one has as yet attempted to identify the cost per student hour of the facility.

Enrollments and Outcomes

The official enrollment area for the college is a seven-county region in western South Carolina, although due to the unique features of the program, individuals from anywhere in the state or outside can apply. Thirty students were admitted to the Automated Manufacturing Technology program the first year: ten from the seven counties near Greenwood, ten came from outside the area but from within South Carolina, and ten more came from out-of-state. This year, to make the program even more accessible, evening courses are being offered.

The Fall 1986 enrollment in the five major programs that use the Robotics Resource Center are:

Automated Manufacturing Technology.....35
Engineering Graphics.....86
Electronics Engineering.....70
General Engineering.....20
Industrial Engineering.....15

Those using the Center are about 10 to 15 percent female (Automated Manufacturing Technology having the lowest percent female enrollment) and about 15 to 20 percent minority. This year, as in the past, about one-third of the students in the Automated Manufacturing Technology Program are from outside the state. The attraction of the program to students from outside the state stands as testimony to the quality, reputation, and regional demand for such a program.

Of last year's graduates, 91 percent either were employed or went on to four-year programs (about half), with average salary of those entering the workforce between $17,000 and $18,000. The two who were not placed were not willing to accept employment out of the local area.

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NOBLE CENTER FOR ADVANCING TECHNOLOGY
OKLAHOMA STATE UNIVERSITY, TECHNICAL BRANCH
OKMULGEE, OKLAHOMA

When George Bragg, President of Telex Corporation and member of the 1986 Commission on the Future of the South, addressed the graduating class of Oklahoma State University's Technical Branch graduating class in the spring of 1986 he concluded with an observation that the nation is entering a new social, technological and economic renaissance period, "led by tremendous advances in science and technology."[21] He encouraged the graduates to "participate in the new renaissance." His comments

reflect the changes that are taking place in technical education, particularly at Oklahoma State, Technical Branch at Okmulgee.

The program at Oklahoma State was selected not only because of its quality, but because it represents a different model for delivering technical education. While the two-year associate degree programs have come to be identified with community colleges and technical institutes, there are still a number of state universities that offer one- and two-year degrees. In contrast to the two-year schools, which were mainly liberal arts programs until the last decade, many of the programs situated on university campuses have been technical.

Since 1946, when it was known as Oklahoma A&M School of Technical Training, the school has graduated more than 25,000 students in vocational fields, including 4,200 electrical-electronic technicians, 3,400 diesel and mechanics technicians, and 900 manufacturing technicians. In 1985, the Oklahoma Board of Regents officially renamed the school Oklahoma State University, Technical Branch.

This year, in order to keep pace with technological advances, Oklahoma State University, Technical Branch dedicated a new multimillion dollar facility, the Noble Center for Advanced Technology. It operates as an interdisciplinary facility with state-of-the-art equipment organized to prepare technically competent and flexible graduates. The Center has four computer-intensive and generic technical areas: information processing, microelectronics, automated manufacturing, and energy. Each area provides the technical skills used in a variety of technical occupations, which brings students from different programs together and produces a cross-fertilization of ideas.

One of the strengths of the university-based two-year program is access to the resources of the university and resident housing, which makes it a state-wide program rather than area-specific. About 45 percent of the students live on-campus. Although the location is rural, it is only about 35 miles from Tulsa, providing access to urban amenities as well as to the technology-based industries in the area. Furthermore, students in four-year institutions usually attend full-time and can devote their full attention to the program rather than have it be an interruption to their worklife.

Faculty, too, are mostly full-time, which means that there must be provisions for sufficient free time so they can update their own technical skills and stay current with technological changes. Much of this occurs during the summer months, with substantial financial support from the Halliburton Foundation.

The academic program includes eleven occupational departments. Some are technology-intensive, such as electrical and electronics technician, manufacturing technician, others use new technologies but do not require the same scientific conceptual skills, such as business and office occupations and construction technology.

This fall the Center is adding a small business incubator for new technologies, which will operate within the Center. Businesses using

the facility must meet three criteria. First, they must be in technological areas that complement the technical education of the Center. Second, they must give employment priority to advanced students in the Center. Third, they must offer opportunities to faculty to stay abreast of technological changes. The first business ready to move in is a water jet cutting business, a new technology that cuts materials under very high water pressure without the distortion caused by heat. The incubator is expected to add an entrepreneurial climate to the technical environment of the Center.

The school also has conducted training programs for industries over the past eight years, but informally and with little publicity. This year, they have institutionalized the program as External Educational Linkages. Through this program the school conducts retraining for local businesses, including their management, and operates as an industrial extension division of the university.

Costs and Revenues

The initial funding for the Noble Center came from the Noble Foundation, which issued a million dollar challenge grant to the Oklahoma Legislature, half of which could be used for the new facility and half for a scholarship endowment fund. The state matched the grant with $1 million and the school contributed about $300,000 for the facility itself.

Most operating funds (three-fourths) come from the state, with the remainder raised from students' tuition payments -- which are $350 per semester for Oklahomans and $1,177 for out-of-state students. About 70 percent of the students receive some sort of tuition aid.

Enrollments and Outcomes

A large majority of the full-time equivalent students (about 90 percent) enroll with the intent of working toward an Associate of Applied Science degree. Due to transfers and attrition, however, about half will actually receive the associate degree. Approximately 90 percent of the students are from the state, with most of the rest from nearby states. The student population is 70-75 percent male, and more than 70 percent Caucasian. About 12 percent of the students are Native Americans, and 16 percent are black, Hispanic, or Asian. Nearly all have high school diplomas and about a fourth have had some college prior to enrollment. Although female enrollment in nontraditional fields has been quite low, the school has experienced recent success in attracting women into Computer-integrated Systems Service, part of the Electronics program. In most programs, however, the enrollment mix follows very traditional lines.

About 4 percent of the graduates go directly to four-year programs and the rest enter the labor market immediately. According to the director, however, about a fourth have gone back to school to complete a baccalaureate degree within ten years after graduating. The graduates of last year's programs did quite well, even in a tight Oklahoma labor market. Graduates of the Manufacturing Technology program began at an

average starting salary of about $21,200; graduates of the Electrical and Electronics Technology program started at about $18,800; those who completed the Robotics (Computer Integrated Systems Service) program began at an average salary of $18,400; and Drafting Technicians began at an average of $16,200.

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BIOMEDICAL EQUIPMENT TECHNOLOGY
STANLY TECHNICAL COLLEGE
ALBEMARLE, NORTH CAROLINA

This year North Carolina, which has perhaps the most extensive system of vocationally oriented community colleges in the nation -- 58 in all -- selected the Biomedical Equipment Technology at Stanly Technical College as its most outstanding program. The two-year associate degree program, which began in 1978, was nominated last year by the state for the Secretary's (of Education) Award for Outstanding Vocational Education Programs. It is especially important to its community because it is in a rural area about 50 miles east of Charlotte, North Carolina. The program has put the community on the world map, attracting visitors from all over the nation and a large number of Far Eastern countries. They come to this rural college to discover what makes it successful and see what they can take back to use as a model.

What makes this particular program, in a region with many good technical programs, so outstanding? First, it faces an enormous responsibility; it tackles a subject area -- medical technology -- where technology is advancing as rapidly as in any field and where decisions quite literally often are made under life or death conditions. Therefore, exceptionally high quality standards must be set for its graduates. It is also a rapidly growing technical field, identified as a critical national need for the future. The utilization of medical equipment is expected to grow by about 16 percent per year, and by 1990 service contracts alone for biomedical products are expected to be over $2 billion.

Graduates have to know more than how to use highly technical and rapidly changing equipment. They must be able to calibrate, adjust, test, and repair it, to teach medical staff how to use it safely, to give advice about new products and help make decisions about purchases and repairs, to interpret codes and regulations for use, to test equipment in patients' homes and in the hospital, to keep accurate technical records, and to generally stay abreast of changes in the technology.

Because technological changes occur quickly in the biomedical field, equipment-specific skills are not sufficient. The graduate has to understand digital and microprocessor systems and fiber optics that

carry the signals as well as possess the problem-solving skills needed to quickly respond to problems and communications skills to teach others.

One of the ways that the program remains current is through its relationship to SunHealth, one of the nation's leading not-for-profit hospital engineering firms. SunHealth helps the program keep its equipment current, informs the staff of current and prospective innovations, and provides instructional assistance and engineering advice. In addition, an advisory board composed of students, graduates, employers, and instructors meets annually to assess program needs and plans and make recommendations.

The curriculum indicates the breadth of the program and the kinds of skills being sought. In addition to the highly technical courses, such as Medical Instrumentation and Biomedical Trouble Shooting Techniques, it includes fundamentals of electronics, chemistry, physics, BASIC, composition, report writing, and oral communications. Students receive 86 hours of classroom theory and lecture in addition to at least 102 hours of labs and hands-on work. The medical technician who can only operate an x-ray machine or pulmonary equipment is very quickly going to become obsolete.

Given the high standards and rigorous requirements of the program, applicants must have strong fundamental skills. Some remedial education is provided, but generally the applicants are screened by high school counselors and advised to apply only when the chance of success is reasonable.

## Costs and Revenues

Student tuition in North Carolina's two-year schools is kept low to make sure that costs do not prohibit access. For in-state students, tuition is only $66 per quarter. Out-of-state students, however, pay $504 per quarter. Because the costs of any program in which the equipment needs constant upgrading are necessarily higher than what can be raised from tuition and state aid, and schools often look for private sector support. Much of the Biomedical Equipment Technology's program's equipment, which is valued at about $1 million, came as gifts from hospitals and medical agencies. In 1986 the program received a grant of $87,800 from the Kate B. Reynolds Foundation to help upgrade its equipment.

The annual expense budget for the program last year was about $84,200, which included $68,800 for operating expenses and $15,400 for capital outlays. Based on enrollments, this represents an annual per pupil expenditure of about $2,550.

## Enrollments and Outcomes

This year there are 32 students enrolled in the program: 25 males, 7 females, 3 minorities, 1 from out of state and 1 from out of the country. Six of the students receive student assistance. Since 1978, 98 percent of the graduates took jobs in the field of medical

instrumentation, and the average starting salary has been between $18,000 and $20,000, although a few have started even higher.

This program, like so many other technology related programs has trouble attracting women and minorities. The biggest barrier to women enrolling, according to a school official, is that many potential female recruits have traditional family roles and are not able to move or travel for employment. Another typically male program in the school, however, electronics technology, has just received a special state grant to encourage female participation. That program is now more than half female, in part as a result of additional tuition assistance, day care options, and travel grants. Plans are underway to extend that process to the Biomedical Equipment Technology and other programs.

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CENTER FOR PRODUCTIVITY, INNOVATION & TECHNOLOGY
CHATTANOOGA STATE TECHNICAL COMMUNITY COLLEGE
CHATTANOOGA, TENNESSEE

Community and technical colleges have historically provided training as a response to industry and local labor-market needs. But under more imaginative and innovative leadership, these schools are taking more proactive roles in local economic development, providing direction and facilitating technology transfer by supplying the technically trained workforce prepared for technological innovation. The technical institute can help fill the gap that exists between the universities that develop new technologies and the businesses that ultimately adopt the technologies.

This is true of Chattanooga State Technical Community College. As a result of an assessment by the college's Futures Committee of local economic needs and the role of the school in economic growth, the college agreed to create a Center for Productivity, Innovation & Technology. The Center, they hoped, by staying on the cutting edge of new manufacturing and design technologies, would help revitalize local businesses and attract technology-based firms. According to an executive vice president of General Electric Company, the Center "will provide the impetus needed to attract new industries to Chattanooga."[22]

Dedicated in March 1984, the Center is believed to be the most sophisticated state-of-the-art automation training facility of any two-year college in the nation. The Center houses a prototype automated factory as well as an automated CAD/CAM center. The core of the program is its electronically controlled systems. The factory includes completely automated flexible manufacturing cells, various kinds of robots, numerically controlled machining centers, quality control units, and a computer aided design/computer aided management (CAD/CAM) center.

When the Center first opened, its equipment already was technically well ahead of the local industries. Oliver Benton, Director of the Productivity Center, notes "it became apparent to us that robots and computers, to be effective, need to be part of an overall system that includes numerical controls, automated materials handling systems, CAD/CAM and so on. Manufacturers will provide the individual pieces, but what industry will really need is someone who can tie the pieces together in a system." The Productivity Center fulfills that function very well. It may be, in fact, the only school in the South that teaches students how to link CAD/CAM with automated manufacturing machinery.

According to the director, the center has three missions: it trains two-year degree students in state-of-the-art technologies; it retrains workers whose skills are becoming obsolete due to technological change; and it consults to industries to help them compete by more effectively utilizing new technologies. The Productivity Center is very much involved with strengthening local industries, which use the Center to upgrade their plants and their workforce, and the Center is very definitely a factor when new industries consider Chattonooga as a location.

When the Center opened, it was expected that retraining would be the most important function, which is how two-year schools have traditionally supported development in the South. As the demand for more flexible, better-trained employees increased, however, more emphasis has been placed on two-year associate degree students and one-year vocational education certificate students. In 1986, about 60 percent of the Center's resources are utilized by students in two associate degree programs: Automated Systems, which is based on electronics principles, and CAD/CAM, which is based on mechanical principles. The faculty are already thinking about expanding and developing a new program for quality control technicians.

Students in these two programs must meet the associate degree requirements of the college, but because the technical programs are more math and science-intensive, in practice students are expected to have even higher levels of proficiency than the average graduate. To qualify for enrollment in the technical programs, about half of the students take remedial math or English before entering. The curriculum requires, in addition to the applied courses, basic theory, such as physics and calculus as well as technical writing, public speaking, and industrial psychology. According to the director, the single most important request from industry leaders was for communication skills -- public speaking and report writing. The development of these skills remains an "absolutely unalterable" part of the Center's training.

The director of the Chattanooga Center pointed out a problem that continues to plague those designing vocational education programs. That is the contradiction between the desire of top management for the "renaissance technician" and the desire of the local personnel officer for more job specific skills. The program is faced with trying to

balance the importance of theory and flexibility with the desire of those doing the local hiring for more traditional traits.

## Costs and Revenues

The Center, valued at over $3 million, was created with $1.3 million that the college had saved in operating funds from previous years, about $400,000 from the Tennessee Valley Authority, and more than $1 million in funds and equipment from the private sector, with a large share coming from General Electric Company. The operating budget for 1986 is about $425,000, but this does not include facility and administrative overhead. About $225,000 comes from industry fees for retraining programs at the facility, $127,000 is from a competitive state grants program, given to good centers with the potential of becoming outstanding, world-class centers. The grant was for the CAD/CAM Center. The Center receives no federal funds from the Carl D. Perkins Vocational Education Act, and thus its students are not included in national vocational education statistics.

The remainder of the budget comes from local industries and foundations with the college covering all overhead (buildings, maintenance, administration, and utilities). Tuition, which is $700 per year, goes directly to the college, not to the programs, and helps pay for overhead costs.

## Enrollments and Outcomes

About 30 students are enrolled in the Associate Degree CAD/CAM program this year and a similar number are in the Automated Systems Program. Based on previous years, about 80 percent will probably complete the course and receive degrees. The Center also is used by about 70 certificate students and a large number of industry employees taking short courses to update their skills and learn how to use new equipment. About one in ten of the participants in the degree and certificate programs is female and about one in eight is minority. The first graduates of the programs (June 1984) all found jobs with salaries averaging $16,000 to $22,000, and most remained in the Chattanooga labor market area.

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Chattanooga, Tennessee 37406

FIGURE 3

CHATTANOOGA STATE (615) 697-4411
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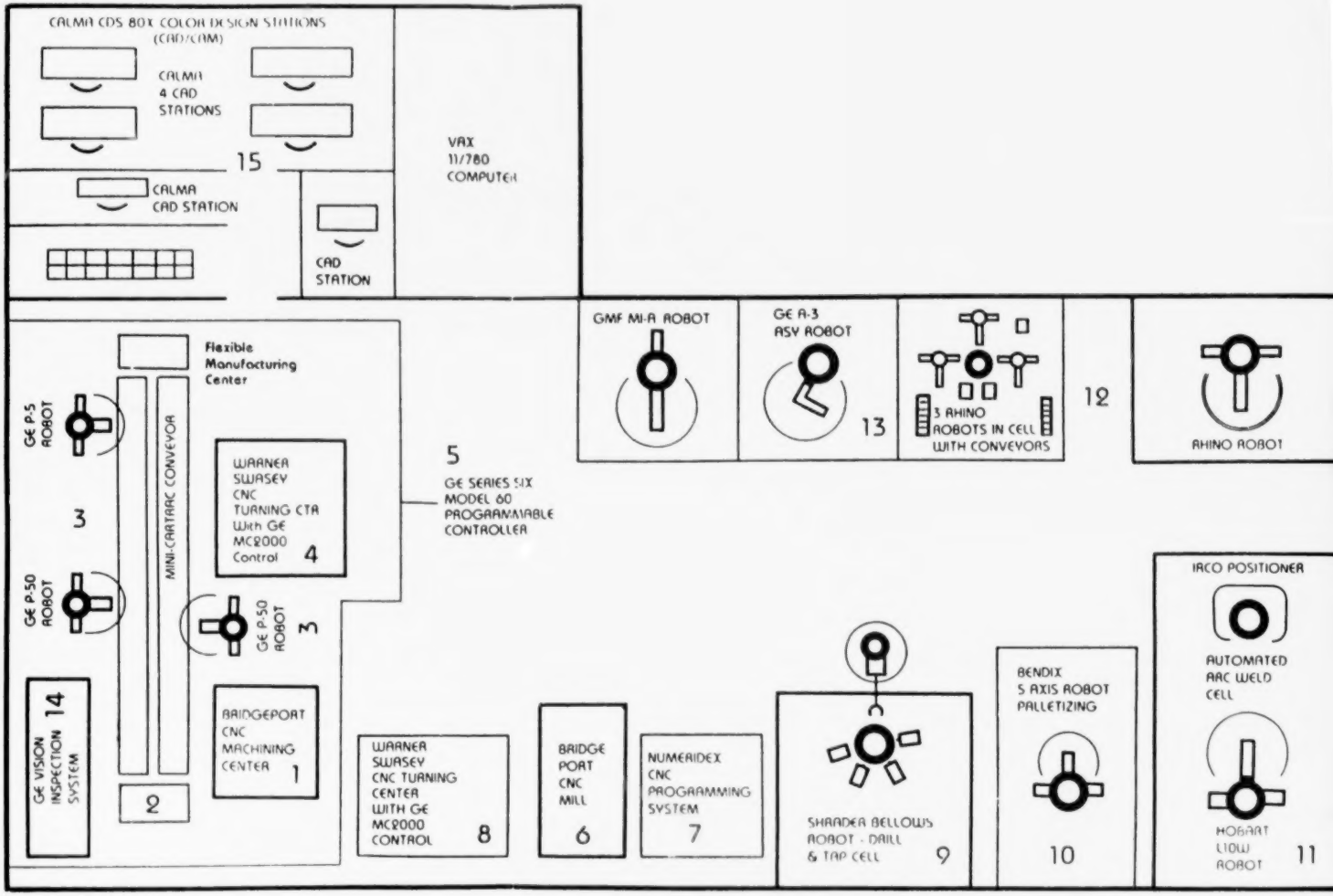

## WINDOW OF OPPORTUNITY AND DOOR TO THE FUTURE-- BUT ALSO ROOM FOR IMPROVEMENT

The programs described represent the best of a certain type of technical education -- that which provides the technical know-how needed in the modern workplace but also prepares an individual for change and advancement and to face and solve technical problems by emphasizing the process of continual learning. The technical strength of the workforce represents one door to the future of the South's economic progress in technology related and technology dependent industries.

Yet there are still nagging questions related to (1) goals, (2) enrollment patterns and access, (3) ability to measure and assess programs, and (4) links to secondary vocational education. While the four programs described are among the best of their kind in the nation, there is still room for improvement as educators face unresolved and potential problems.

The first problem is the contradiction between the qualities of technicians wanted by corporate management and those sought by the plant or office level personnel manager. Some program administrators expressed frustration over trying to provide the broad-based skills needed for the future while still meeting the more parochial requirements of those doing the actual hiring. Further, even where work is organized to share responsibility and authority, few companies extend that cooperative arrangement between management and employees to major decisions. Technical associate degree programs rarely include units on business or finance, which would strengthen the technician's understanding of and ability to participate in resource allocation decisions.

Another goal that ought to be clarified is whether the technical programs are considered as primarily preparation for employment or as preparation for further education in four-year schools. About half the graduates of the South Carolina program go on to higher education. A large number of those completing the Oklahoma program eventually get baccalaureate degrees, but generally only after working in a technical field for a number of years. Continuing education, in fact, may be what industry desires. According to Dr. Ray Morrison, in Georgia "industry wants the associate degree students and they want them to have the ability to go on for further education, but not immediately. They like the formula of work following the degree and then being able to influence and help with further education."

The second problem is the inability to attract women and minorities -- who will comprise a majority of future workforce entrants over the rest of this century -- into technical programs. Two reasons are given: one is that women and minorities do not apply and prefer other, less technical fields; the other is that the most qualified are highly sought by universities and choose to enter four-year professional programs. Although all states provide equal opportunities, only North Carolina, among the states contacted, described special efforts to recruit women and minorities into its technical programs.

A third issue is whether these programs, all of which are relatively new, will be able to stay abreast of technological change, both with their equipment and their faculty. State government and the private sector have been relatively generous in getting the programs going, but they will not remain in the forefront of new technologies without continual updating and replacing of equipment and reeducating teachers. The investments are not long-term, as an investment in a new building might be. The technological life of automated equipment is relatively short. Faculty can keep up in two ways. One is through exchanges with industry, spending some time with industry. The other, recently recommended by the National Science Foundation, is that states ought to create opportunities for technical faculty to interact with faculty at research institutions.[23]

Fourth, it is important to be able to evaluate and measure the outcomes of the investments, but the data for such analyses are growing more scarce instead of more reliable and available. When the Congress mandated a vocational education data system in 1976, they expected to have uniform data across states by now. Instead, there are many state systems with different ways of classifying students and programs based on institutional setting, length of training, and source of funding. Since the federal government seems to be getting out of the business of collecting and providing data, the southern states ought to try to develop a classification scheme of their own for technically trained personnel.

Last, and important for state policy makers, is what kind of preparation in the secondary schools is most appropriate for continuing on to postsecondary technical programs. It is clear that basic skills requirements are important; nearly half of the students entering technical programs need remedial work first. One way that high school vocational education is responding now is with a technical cluster called Principles of Technology, a less-specialized program that provides the generic technical competencies to students interested in pursuing technical careers. The two-year schools are going to have to work much more closely with the high schools in articulating the two sets of programs.

There is clearly a strong role for two-year schools in preparing and maintaining a technically trained workforce. As the high schools turn toward better accomplishing the basic requirements of public education -- whether in an academic or vocational setting -- the two-year schools will increasingly be expected to provide the skills and knowledge necessary to use, understand, and control new technologies.

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